Informal meeting on Code of Practice for Packing of Cargo Transport Units

at the request of the United Nations Economic Commission for Europe Working Party on Intermodal Transport and Logistics

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Dunnage bags

Submitted by the Russian Federation

Introduction

This document proposes addition to the Appendix 4 of Annex 7, section 4 on Cargo securing with dunnage bags. The proposed new text is marked in red.

4 Cargo securing with dunnage bags

4.1 Introduction

4.1.1 Accelerations in different directions during transport may cause movements of cargo, either sliding or tipping. Dunnage bags, or air bags, used as blocking devices may be able to prevent these movements.

4.1.2 The size and strength of the dunnage bag are to be adjusted to the cargo weight so that the permissible ~~lashing~~ Blocking Capacity of the dunnage bag, without risk of breaking it, is larger than the force the cargo needs to be supported with:

BC ~~$F_{DUNNAGE\ BAG}$~~ ≥ F_{CARGO}

4.2 Force on dunnage bag from cargo (F_{CARGO})

4.2.1 The maximum force, with which rigid cargo may impact a dunnage bag, depends on the cargo's mass, size and friction against the surface and the dimensioning accelerations according to the formulas below:

Sliding:	Tipping:
$F_{CARGO} = m \cdot g \cdot (c_{x,y} - \mu \cdot 0.75 \cdot c_z)$ [kN]	$F_{CARGO} = m \cdot g \cdot (c_{x,y} - b_p/h_p \cdot c_z)$ [kN]

F_{CARGO} = force on the dunnage bag caused by the cargo ~~[t]~~ [kN]
m = mass of cargo [tonnes]
$c_{x,y}$ = Horizontal acceleration, expressed in *g*, that acts on the cargo ~~sideways~~ longitudinal or transverse ~~or in forward or backward~~ directions
c_z = Vertical acceleration that acts on the cargo, expressed in *g*
μ = Friction factor for the contact area between the cargo and the ~~surface~~ cargo deck or between different packages
b_p = Package width for tipping sideways, or alternatively the length of the cargo for tipping forward or backward
h_p = package height [m]

4.2.2 The load on the dunnage bag is determined by the movement (sliding or tipping) and the mode of transport that gives the largest force on the dunnage bag from the cargo.

4.2.3 Only the cargo mass that actually ~~impacts~~ acts on the dunnage bag that should be used in the above formulas. If the dunnage bag is used to prevent movement forwards, when breaking for example, the mass of the cargo behind the dunnage bag should be used in the formulas.

4.2.4 If the dunnage bag instead is used to prevent movement sideways, the largest total mass of the cargo that either is on the right or left side of the dunnage bag should be used, that is, either the mass m_1 or m_2 (see figure 7.59).

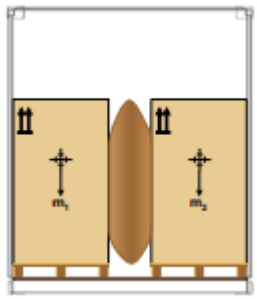

Figure 7.59 Equal height packages

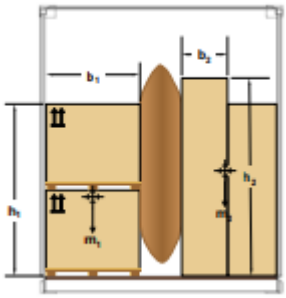

Figure 7.60 Unequal height packages

4.2.5 In order to have some safety margin in the calculations, the lowest friction factor should be used, either the one between the cargo in the bottom layer and the platform or between the layers of cargo.

4.2.6 If the package on each side of the dunnage bag has different forms, when tipping the relationship between the cargo width and height of the cargo stack that has the smallest value of b_p / h_p is chosen.

4.2.7 However, in both cases the total mass of the cargo that is on the same side of the dunnage bag should be used, that is, either the mass m1 or m2 in figure 7.60.

4.3 ~~Permissible load on the dunnage bag –~~ Blocking Capacity of the dunnage bag (BC ~~F_{DB}~~)

4.3.1 The force that the dunnage bag is able to ~~take up~~withstand, i.e. its Blocking Capacity, depends on the area of the dunnage bag which the cargo is resting against and the maximum allowable working pressure. The force of the dunnage bag is calculated from:

$$BC\ F_{DB} = A \cdot 10 \cdot g \cdot P_B \cdot SF\ [kN]$$

BC F_{DB} = force that the dunnage bag is able to take up without exceeding the maximum allowable pressure, i.e its Blocking Capacity (kN)

P_B = bursting pressure of the dunnage bag [bar]

A = contact area between the dunnage bag and the cargo [m^2]

SF = safety factor

0.75 for single use dunnage bags

0.5 for reusable dunnage bags

4.4 Contact area (A)

4.4.1 The contact area between the dunnage bag and the cargo depends on the size of the bag before it is inflated and the gap that the bag is filling. This area may be approximated by the following formula:

$$A = (b_{DB} - \pi \cdot d/2) \cdot (h_{DB} - \pi \cdot d/2)$$

b_{DB} = width of dunnage bag [m]

h_{DB} = height of dunnage bag [m]

A = contact area between the dunnage bag and the cargo [m2]

d = gap between packages [m]

π = 3.14

~~4.4.2 When a dunnage airbag is used to secure a load, its working height must not exceed the height of the load or the wall of an open vehicle. The airbag must be inflated to operating pressure, taking into account the climatic conditions along the route of the cargo in accordance with the manufacturer's recommendations, in order to make it operational.~~

4.4.~~3~~2. ~~After installation, the contact surface area of the airbag must cover at least half of the surface area of the load.~~ In order to provide a sufficient ~~the required~~ contact area, neither the width nor the height of the dunnage bag should be less than 2.5 times the ~~for a given~~ size of the filled gap, ~~dunnage airbags must be used of permissible dimensions are shown in table X~~.

~~Table X Minimum permissible dunnage airbag length depending on fillable gap and airbag width.~~

~~Dunnage airbag width B_n, cm~~	~~Fillable gap size H, cm~~							
	~~10~~	~~15~~	~~20~~	~~25~~	~~30~~	~~35~~	~~40~~	~~45~~
	~~Minimum permissible dunnage airbag length L_n, cm~~							
~~60~~	~~60~~	~~60~~	~~145~~	~~-~~	~~-~~	~~-~~	~~-~~	~~-~~
~~70~~	~~70~~	~~70~~	~~95~~	~~285~~	~~-~~	~~-~~	~~-~~	~~-~~
~~80~~	~~80~~	~~80~~	~~80~~	~~145~~	~~-~~	~~-~~	~~-~~	~~-~~
~~85~~	~~85~~	~~85~~	~~85~~	~~125~~	~~305~~	~~-~~	~~-~~	~~-~~
~~90~~	~~90~~	~~90~~	~~90~~	~~115~~	~~220~~	~~-~~	~~-~~	~~-~~
~~100~~	~~100~~	~~100~~	~~100~~	~~100~~	~~155~~	~~335~~	~~-~~	~~-~~
~~120~~	~~120~~	~~120~~	~~120~~	~~120~~	~~120~~	~~175~~	~~290~~	~~-~~
~~150~~	~~150~~	~~150~~	~~150~~	~~150~~	~~150~~	~~150~~	~~170~~	~~235~~

4.4.4 When a dunnage bag is used to secure a load, its working height must not exceed the height of the ~~load~~ cargo or the boundary wall of an open vehicle. The maximum permissible ~~size~~ height of a dunnage ~~air~~bag ~~($B_n \times L_n$)~~ can be determined depending on the ~~size~~ height of the ~~goods~~ cargo ~~($B_{FP} \times L_{FP}$)~~ by using the following formula~~s~~:

$$B_{п} = B_{гр} + \frac{\pi - 2}{2} H$$

$$L_{п} = L_{гр} + \frac{\pi - 2}{2} H$$

$$h_{DB} = h + (\pi - 1) \cdot d / 2$$

h_{DB} = height of dunnage bag [m]

h = height of cargo [m]

d = gap between packages [m]

π = 3.14

4.5 Pressure in the dunnage bag

4.5.1 To be fully effective the~~The airbag~~ dunnage bag must be inflated to its operating pressure, taking into account the climatic conditions along the route of the ~~cargo~~ CTU and in accordance with the manufacturer's recommendations~~, in order to make it operational~~. This may require that ~~Upon application of~~ the dunnage bag ~~it~~ is filled to a slight overpressure so that if the ambient pressure rises or the air temperature falls there is no risk that the dunnage bag may become loose. ~~If this pressure is too low there is a risk that the dunnage bag may come loose if the ambient pressure is rising or if the air temperature drops.~~ Conversely, if the filling pressure is too high there is a risk of the dunnage bag bursting or damaging the cargo if the ambient pressure decreases, or if the air temperature rises.

4.5.2 The bursting pressure (PB) of a dunnage bag depends on the quality and size of the bag and the gap that it is filling. The pressure exerted on a dunnage by the cargo forces should never be allowed to approach bursting pressure of the bag because of the risk of failure. A safety factor should, therefore, be incorporated and, if necessary, a dunnage bag with a higher bursting pressure selected.

4.5.3 Dunnage bags mark with Level 1 to 5 according to the Association of American Railroads criteria have the following minimum bursting pressure:

Level 1 - 0.55 bar

Level 2 - 1.2 bar

Level 3 - 1.7 bar

Level 4 - 2.1 bar

Level 5 - 1.5 bar

Level 1 ~~through~~ to 4 dunnage bags are tested at a gap of 30 cm while Level 5 dunnage bags are tested at a gap of 46 cm.

4.6 Recommended marking for dunnage bags

~~Dependence of maximum permissible load, example for Level 4, Heavy (Grand) type dunnage airbag on its size and the size of the void to be filled.~~
~~Dimensions (cm)~~

	~~Fillable gap size~~	~~60x110~~	~~85x120~~	~~100x140~~	~~100x185~~	~~100x220~~	~~120x180~~	~~120x240~~
~~Load in tons~~	~~10 cm~~	~~8.5~~	~~13.5~~	~~19.0~~	~~26.0~~	~~30.5~~	~~38.0~~	~~42.0~~
	~~20 cm~~	~~4.0~~	~~7.5~~	~~12.0~~	~~16.5~~	~~20.5~~	~~29.0~~	~~30.0~~
	~~45 cm~~	~~n/a~~	~~n/a~~	~~2.0~~	~~3.5~~	~~4.5~~	~~12.0~~	~~15.0~~

Blocking capacity of various size dunnage bags marked Level 3 and having a bursting pressure of 1.7 bar at a gap of 30 cm.

	Fillable gap size	**Bursting pressure**	**Dimensions (cm)**				
			60 x 100	**100 x 120**	**100 x 150**	**120 x 200**	**120 x 250**
Blocking capacity [tons]	10 cm	2.3 bar	4.2	10	13	22	28
	20 cm	2.0 bar	1.9	6.0	8.1	15	19
	30 cm	1.7 bar	n/a	3.3	4.6	9.5	13
	45 cm	1.3 bar	n/a	n/a	n/a	4.1	5.6